A real world 1D stock cutting problem: exact and heuristic algorithms

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1 Introduction and problem description

In a modern joinery shop floor, profiles are cut from different materials (e.g. wood, aluminium and plastics) with different properties (e.g. color). For constructing door and window frames, the profiles need to be cut under varying angles, in order to make assembly possible. The process of cutting materials also causes losses proportional to the width of the saw blade and dependent on the angle under which the material is being cut. Lastly, cutting stock generates leftover material that sometimes still has some value. Companies are interested in reusing these leftover pieces in order to minimize waste and to reduce costs. All these factors result in the real world stock cutting problem that we will present.

The problem can be formulated as follows: assume a set W of work pieces w_i ($w_i \in W$) that can be cut from a set T of different stock trade lengths t_j ($t_j \in T$), with the possibility of reusing as many pieces s_k as possible from a set S ($s_k \in S$) of leftover pieces.We take into account the following additional constraints and requirements. First of all, the trade lengths and leftover pieces are not directly usable due to possible damage in storage. Thus, we need to subtract some length l_{loss} from the original length so that we have a usable length $t_j^{usable} = t_j - l_{loss}$. Saw blade losses depending on the angles of the pieces must also be taken into account. This is sb_{loss}^{45} for 45 degree angles and sb_{loss}^{90} for 90 degree angles. The order in which pieces are cut also becomes important: if a piece ends with a cut of 90 degrees and the next piece begins with a cut of 90 degrees, then these 2 cuts can be performed with a single saw blade movement and induce one loss only. Finally, for symmetric profiles we can benefit from rotating some pieces, and thus cutting 2 pieces with one movement. The objective is to minimize the number of trade lengths to order. In addition to this, leftover pieces are preferably smaller than 50mm (=waste) or larger than 500mm (leftover piece that probably can be reused).

We give a brief introduction to a comparative study of recent optimisation methods for this real world stock cutting problem. We will look at both exact and heuristic algorithms.

2 Methods

Cutting and packing problems are well studied in the literature and many methods are available to solve them. We make a comparison of some recent methods, based on their performance on the real world problem. The methods we tested are the following:

Exact methods: We will investigate which exact methods exist for solving stock cutting and bin packing problems, and we will look into methods for adjusting them to handle real world constraints and requirements.

Heuristics: We will test simple and fast heuristic methods like the Decreasing First/Best Fit heuristic, as well as some more complicated heuristics such as Minimal Bin Slack (MBS), which is described in [1]. The MBS heuristics use a smart recursive method that minimizes the slack of a bin. Furthermore, it is combined with an even better performing variable neighbourhood search method. Lastly, we also developed a hyperheuristic method using low-level heuristics such as swaps, transfers and perturbations.

3 Experiments

In order to evaluate the performance of the different approaches for this stock cutting problem, we used real world data from different client orders from joineries. These datasets contain problems ranging up to 1000 work pieces, trade lengths ranging from $5400mm$ to $7000mm$, and a set of variably sized leftover pieces.

4 Discussion

This abstract introduces a comparative study of combinatorial optimisation methods for a real world stock cutting problem. The first results show improvements of about 1% compared to currently used methods in practice.

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References

[1] K. Fleszar and K. S. Hindi. New heuristics for one-dimensional bin-packing. *Computers & Operations Research*, 29:821–839, 2002.